Unofficial User's Guide to Interfacing FAST with OrcaFlex

This document describes the process to couple OrcaFlex with FAST. The FASTORCA.exe, FASTORCA.bat and DFORRT.dll files should be downloaded and saved on your computer before constructing the model. Installation of FASTORCA.exe should follow the same extraction process outlines in Buhl [1]. The available FASTORCA.exe executable is precompiled to interface with OrcaFlex; therefore no further actions, other than constructing the wind turbine model in OrcaFlex and including light modifications to the FAST input files, is needed to proceed with the modeling. The modifications needed in FAST version v7.00.01a-bjj to produce the FASTORCA.exe executable are explained in Section 4.

The source code modifications needed to couple FAST with OrcaFlex was developed by Antione Peiffer, of Principle Power, in collaboration with Orcina, the creators of OrcaFlex.

1. Modifying the FAST Input File

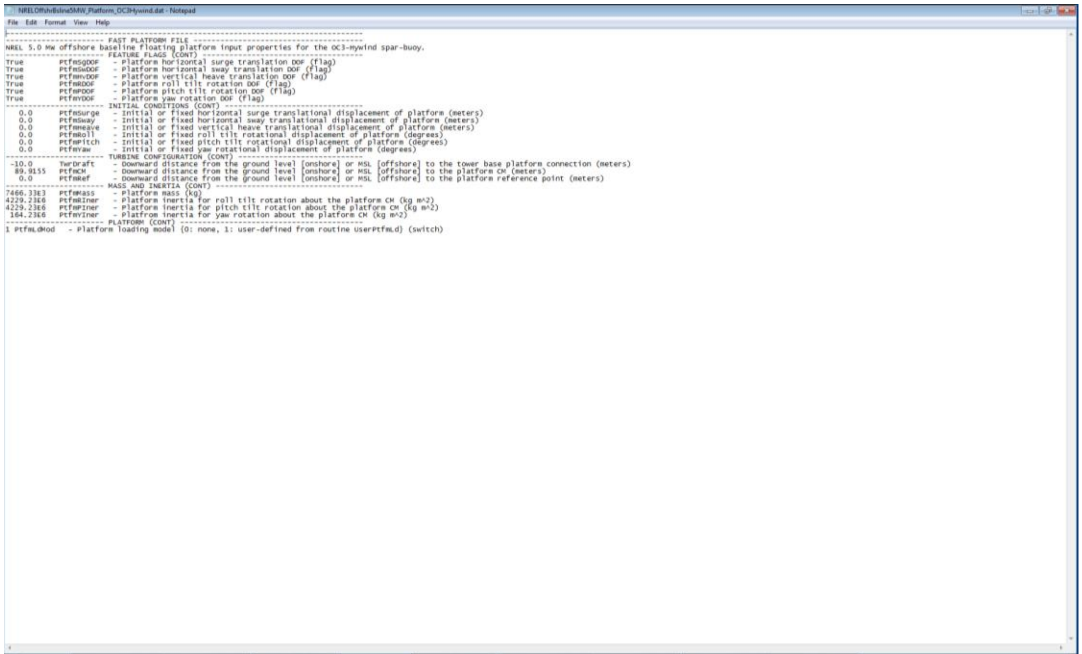
OrcaFlex replaces the HydroDyn module within FAST. HydroDyn is responsible for calculating the:

- Hydrodynamic force on the platform, which includes the radiation, diffraction added mass and quadratic drag terms
- Mooring line restoring forces via a quasi-static approximation methods using a closed-form continuous cable analytical model

OrcaFlex will replace these functionalities, and in order to accomplish this task, the FAST input files must be modified to reflect exchanged responsibilities, i.e., in other words, HydroDyn will be replaced by OrcaFlex. The unmodified FAST platform input file should appear similar to Figure 1. To inform FAST that HydroDyn is being replaced with OrcaFlex, `PtfmLdMod` is changed from `FltngPtfmLd` to `1`. All data below this line can then be discarded, if desired, since it is no longer needed by FAST (the discarded information will be included in the OrcaFlex model). The newly acquire platform input file should appear similar to Figure 2.

```
NRELOffshrBsline5MW_Platform_OC3Hywind.dat - Notepad
File  Edit  Format  View  Help
--------------------------------------------------------------------------------
---------------------- FAST PLATFORM FILE ---------------------------------------
NREL 5.0 MW offshore baseline floating platform input properties for the OC3-Hywind spar-buoy.
---------------------- FEATURE FLAGS (CONT) -------------------------------------
True          PtfmSgDOF    - Platform horizontal surge translation DOF (flag)
True          PtfmSwDOF    - Platform horizontal sway translation DOF (flag)
True          PtfmHvDOF    - Platform vertical heave translation DOF (flag)
True          PtfmRDOF     - Platform roll tilt rotation DOF (flag)
True          PtfmPDOF     - Platform pitch tilt rotation DOF (flag)
True          PtfmYDOF     - Platform yaw rotation DOF (flag)
---------------------- INITIAL CONDITIONS (CONT) --------------------------------
   0.0        PtfmSurge    - Initial or fixed horizontal surge translational displacement of platform (meters)
   0.0        PtfmSway     - Initial or fixed horizontal sway translational displacement of platform (meters)
   0.0        PtfmHeave    - Initial or fixed vertical heave translational displacement of platform (meters)
   0.0        PtfmRoll     - Initial or fixed roll tilt rotational displacement of platform (degrees)
   0.0        PtfmPitch    - Initial or fixed pitch tilt rotational displacement of platform (degrees)
   0.0        PtfmYaw      - Initial or fixed yaw rotational displacement of platform (degrees)
---------------------- TURBINE CONFIGURATION (CONT) -----------------------------
 -10.0        TwrDraft     - Downward distance from the ground level [onshore] or MSL [offshore] to the tower base platform connection (meters)
  89.9155     PtfmCM       - Downward distance from the ground level [onshore] or MSL [offshore] to the platform CM (meters)
   0.0        PtfmRef      - Downward distance from the ground level [onshore] or MSL [offshore] to the platform reference point (meters)
---------------------- MASS AND INERTIA (CONT) ----------------------------------
7466.33E3     PtfmMass     - Platform mass (kg)
4229.23E6     PtfmRIner    - Platform inertia for roll tilt rotation about the platform CM (kg m^2)
4229.23E6     PtfmPIner    - Platform inertia for pitch tilt rotation about the platform CM (kg m^2)
 164.23E6     PtfmYIner    - Platfrom inertia for yaw rotation about the platform CM (kg m^2)
---------------------- PLATFORM (CONT) ------------------------------------------
FltngPtfmLd PtfmLdMod    - Platform loading model {0: none, 1: user-defined from routine UserPtfmLd} (switch)
"HydroData\Spar"                          WAMITFile    - Root name of WAMIT output files containing the linear, nondimensionalized, hydrostatic restoring matrix (.hst extension), frequency-dependent hydrodynamic added mass matrix a
8029.21       PtfmVol0     - Displaced volume of water when the platform is in its undisplaced position (m^3) [USE THE SAME VALUE COMPUTED BY WAMIT AS OUTPUT IN THE .OUT FILE!]
 240          PtfmNodes    - Number of platform nodes used in calculation of viscous drag term from Morison's equation (-)
 120.0        PtfmDraft    - Effective platform draft    in calculation of viscous drag term from Morison's equation (meters)
   6.5        PtfmDiam     - Effective platform diameter in calculation of viscous drag term from Morison's equation (meters)
   0.6        PtfmCD       - Effective platform normalized hydrodynamic viscous drag coefficient in calculation of viscous drag term from Morison's equation (-)
  60.0        RdtnTMax     - Analysis time for wave radiation kernel calculations (sec) [determines RdtnDOmega=Pi/RdtnTMax in the cosine transform]  [MAKE SURE THIS IS LONG ENOUGH FOR THE RADIATION IMPULSE RESPONSE FUNCTIONS TO DECAY TO NEA
   0.025      RdtnDT       - Time step for wave radiation kernel calculations (sec) [DT<=RdtnDT<=0.1 recommended] [determines RdtnOmegaMax=Pi/RdtnDT in the cosine transform]
---------------------- MOORING LINES --------------------------------------------
   3          NumLines     - Number of mooring lines (-)
   1          LineMod      - Mooring line model {1: standard quasi-static, 2: user-defined from routine UserLine} (switch) [used only when NumLines>0]
LRadAnch  LAngAnch  LDpthAnch  LRadFair  LAngFair  LDrftFair  LUnstrLen  LDiam  LMassDen  LEAStff    LSeabedCD  LTenTol [used only when NumLines>0 and LineMod=1]
(m)       (deg)     (m)        (m)       (deg)     (m)        (m)        (m)    (kg/m)    (N)        (-)        (-)     [used only when NumLines>0 and LineMod=1]
 853.87     0.0     320.0      5.2         0.0     70.0       902.2      0.09   77.7066   384.243E6  0.0        0.0000001
 853.87   120.0     320.0      5.2       120.0     70.0       902.2      0.09   77.7066   384.243E6  0.0        0.0000001
 853.87   240.0     320.0      5.2       240.0     70.0       902.2      0.09   77.7066   384.243E6  0.0        0.0000001
---------------------- WAVES ----------------------------------------------------
1025.0        WtrDens      - Water density (kg/m^3)
 320.0        WtrDpth      - Water depth (meters) [USE THE SAME VALUE SPECIFIED IN THE WAMIT .POT FILE!]
   0          WaveMod      - Incident wave kinematics model {0: none=still water, 1: plane progressive (regular), 2: JONSWAP/Pierson-Moskowitz spectrum (irregular), 3: user-defind spectrum from routine UserWaveSpctrm (irregular)} (switch)
3630.0        WaveTMax     - Analysis time for incident wave calculations (sec) [unused when WaveMod=0] [determines WaveDOmega=2Pi/WaveTMax in the IFFT]
   0.25       WaveDT       - Time step for incident wave calculations (sec) [unused when WaveMod=0] [0.1<=WaveDT<=1.0 recommended] [determines WaveOmegaMax=Pi/WaveDT in the IFFT]
   6.0        WaveHs       - Significant wave height of incident waves (meters) [used only when WaveMod=1 or 2]
  10.0        WaveTp       - Peak spectral period of incident waves (sec) [used only when WaveMod=1 or 2]
DEFAULT       WavePkShp    - Peak shape parameter of incident wave spectrum (-) or DEFAULT (unquoted string) [used only when WaveMod=2] [use 1.0 for Pierson-Moskowitz]
   0.0        WaveDir      - Incident wave propagation heading direction (degrees) [unused when WaveMod=0]
123456789     WaveSeed(1) - First  random seed of incident waves [-2147483648 to 2147483647] (-) [unused when WaveMod=0]
1011121314    WaveSeed(2) - Second random seed of incident waves [-2147483648 to 2147483647] (-) [unused when WaveMod=0]
---------------------- CURRENT --------------------------------------------------
   0          CurrMod      - Current profile model {0: none=no current, 1: standard, 2: user-defined from routine UserCurrent} (switch)
   0.0        CurrSSV0     - Sub-surface current velocity at still water level (m/s) [used only when CurrMod=1]
DEFAULT       CurrSSDir    - Sub-surface current heading direction (degrees) or DEFAULT (unquoted string) [used only when CurrMod=1]
  20.0        CurrNSRef    - Near-surface current reference depth (meters) [used only when CurrMod=1]
   0.0        CurrNSV0     - Near-surface current velocity at still water level (m/s) [used only when CurrMod=1]
   0.0        CurrNSDir    - Near-surface current heading direction (degrees) [used only when CurrMod=1]
   0.0        CurrDIV      - Depth-independent current velocity (m/s) [used only when CurrMod=1]
   0.0        CurrDIDir    - Depth-independent current heading direction (degrees) [used only when CurrMod=1]
---------------------- OUTPUT (CONT) --------------------------------------------
   1          NWaveKin     - Number of points where the incident wave kinematics can be output [0 to 9] (-)
 240          WaveKinNd    - List of platform nodes that have wave kinematics sensors [1 to PtfmNodes] (-) [unused if NWaveKin=0]
```

Figure 1: Original `NRELOffshrBsline5MW_Platform_OC3Hywind.dat` file.



NRELOffshrBsline5MW_Platform_OC3Hywind.dat - Notepad

File Edit Format View Help

```
-------------------------------------------------------------------------------
--------------------- FAST PLATFORM FILE --------------------------------------
NREL 5.0 MW offshore baseline floating platform input properties for the OC3-Hywind spar-buoy.
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True         PtfmHvDOF   - Platform vertical heave translation DOF (flag)
True         PtfmRDOF    - Platform roll tilt rotation DOF (flag)
True         PtfmPDOF    - Platform pitch tilt rotation DOF (flag)
True         PtfmYDOF    - Platform yaw rotation DOF (flag)
--------------------- INITIAL CONDITIONS (CONT) -------------------------------
   0.0       PtfmSurge   - Initial or fixed horizontal surge translational displacement of platform (meters)
   0.0       PtfmSway    - Initial or fixed horizontal sway translational displacement of platform (meters)
   0.0       PtfmHeave   - Initial or fixed vertical heave translational displacement of platform (meters)
   0.0       PtfmRoll    - Initial or fixed roll tilt rotational displacement of platform (degrees)
   0.0       PtfmPitch   - Initial or fixed pitch tilt rotational displacement of platform (degrees)
   0.0       PtfmYaw     - Initial or fixed yaw rotational displacement of platform (degrees)
--------------------- TURBINE CONFIGURATION (CONT) ----------------------------
 -10.0       TwrDraft    - Downward distance from the ground level [onshore] or MSL [offshore] to the tower base platform connection (meters)
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 164.23E6    PtfmYIner   - Platfrom inertia for yaw rotation about the platform CM (kg m^2)
--------------------- PLATFORM (CONT) -----------------------------------------
1 PtfmLdMod   - Platform loading model {0: none, 1: user-defined from routine UserPtfmLd} (switch)
```

Figure 2: NRELOffshrBsline5MW_Platform_OC3Hywind.dat after modification.

2. Constructing the OrcaFlex Model

The sample OrcaFlex simulation file NRELOffshrBsline5MW_Floating_OC3Hywind.sim is pre-assembled and ready to be run with FASTORCA. The steps taken to arrive at this point are described in the following 16 steps.

1. Rename the OrcaFlex simulation file to have the identical name as the FAST input file. That is, <file_name>.sim and <file_name>.fst should read the same, except for their filename extensions. Both the <file_name>.sim and <file_name>.sim must be saved in the same folder.
2. In the Model Browser, double click on 'Variable Data'. In the 'Data Source Type' panel, select 'External Functions'. Add one 'Number of data sources', and rename 'ExternalFunction1' to 'ExtFn'. Select the FASTlinkDLL.dll file. For the 'Function Name', select ExtFn.
3. In the Model Browser, go to General -> Integration and Time Step -> Integration Method, and set this value to Implicit. Figure 4 graphically outlines steps 2-5.
4. Insert a new vessel. In the Model Browser, go to Vessel1 -> Calculation Integration and Time Step -> Integration Method -> Primary Motion, and check the Externally Calculated radio button. Rename Vessel1 to Platform. In the Superimpose Motion box, check None.
5. In the same frame, it is equally important to check the correct tabs in the Included Effects frame to incorporate the relevant external forces, as well as and those represented in the WAMIT input file. Wind Damping does not need to be selected because these forces are solved by the FAT executable, FASTORCA.exe. In the case of the NRELOffshrBsline5MW_Floating_OC3Hywind.sim example, the following effects are included:
   a. Applied Loads
   b. Hydrodynamic Damping
   c. Wave Loads (1st Order)
   d. Added Mass and Damping

   Note that the 2nd order wave drift loads are not included in the WAMIT input files we provide, and the Applied Loads value will be defined in a later section. The Vessel Initial Position is prescribed at this juncture, which presumably is (0,0,0). If not, this value must be modified in both OrcaFlex and in the FAST input file, NRELOffshrBsline5MW_Platform_OC3Hywind.dat.

6. Click on the '`Primary Motions`' tab, and under the 'Externally calculated primary motion:' box, select 'ExtFn'.
7. At this stage, I would suggest changing the vessel geometry to reflect an appearance representative of the system being modeled. This step is optional, but it will help with visualizing the mooring/vessel connection profile and vessel motions after the simulation is completed. To do so, proceed to the `Vessel Type` tab and modify the `Vertices` in the `Drawing` tab to add lines and vertices to the vessel.

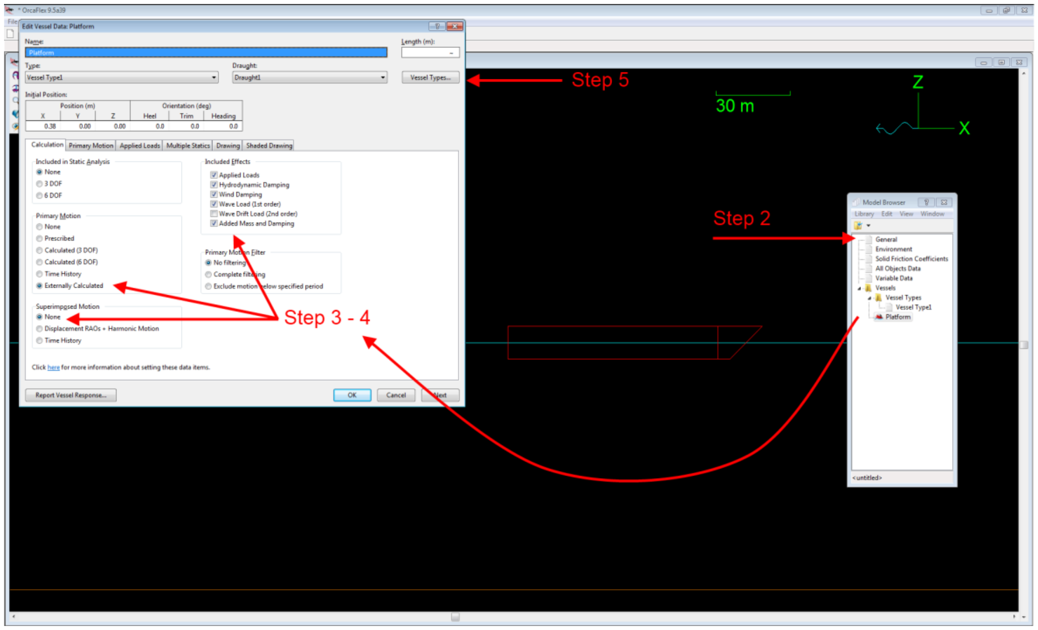

Figure 3

8. Vessel shape can be modified by changing the vertices location and line diameter. Figure 4 shows steps 6 - 8.
9. Next, on the bottom of the same frame, click on `Import Hydrodynamic Data…` and import the `spar2.out` WAMIT file
10. In the same frame, click on `Structure` and insert small values to give the platform insignificant inertia properties. We do this because the platform mass properties are defined in FAST.

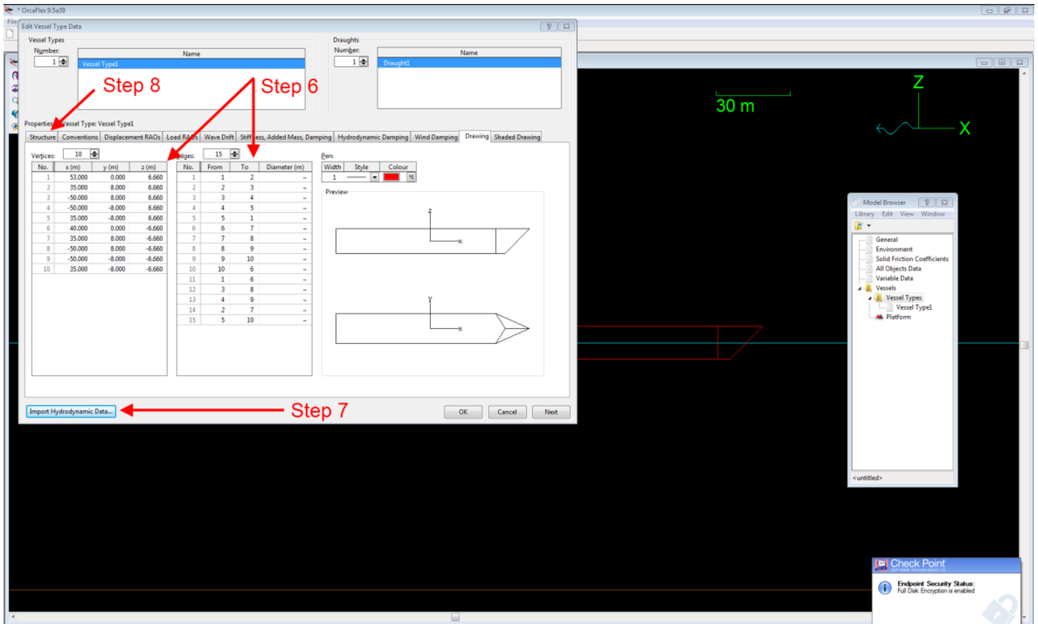

Figure 4

11. In the `Model Browser`, go to `Environment -> Seabed`, and prescribe the water depth. If desired, the wave properties can be given at this step. I usually set the wave input parameters as a last step, prior to performing the simulation.
12. The mooring can now be presented in the model. To do so, click on the `New Line` icon on the toolbar and add a mooring line to the model. Be sure to fix one end of the mooring line to the seabed and the opposite end to the platform. Figure 5 illustrates steps 10 – 12.
13. Next, give the `Object Relative Position` of the mooring lines relative to 1) the platform and 2) the seabed origin.
14. Under Line Type1 in the `Model Browser`, define the line attributes and properties.

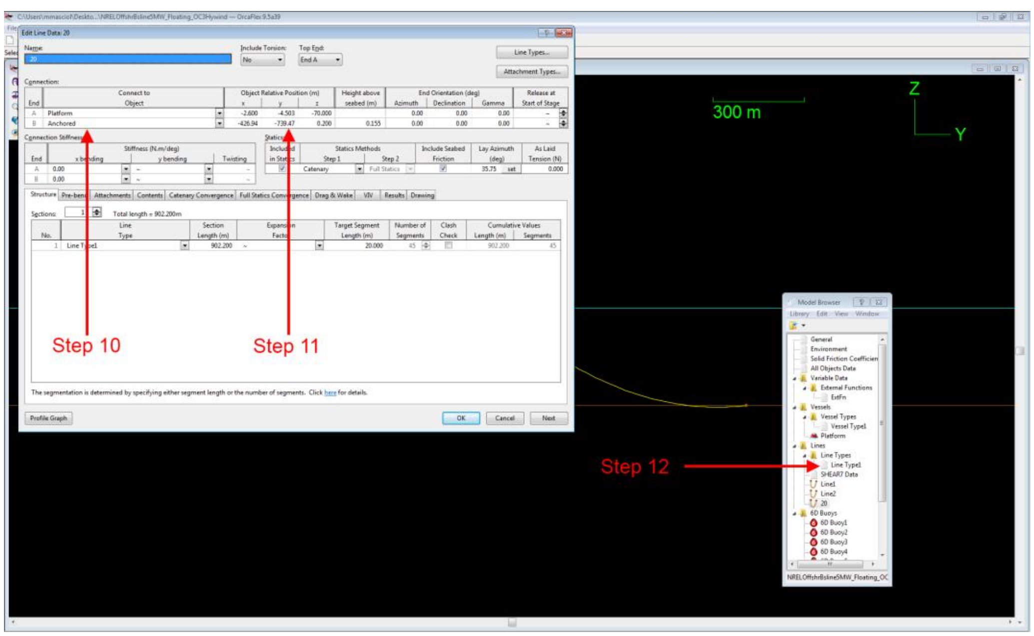

Figure 5

15. The next step in the assembly of the model is to include 6D buoys so that the quadratic drag term in Morison's equation is included as a force on the spar body. To do this, click on `New 6D`

`Buoy` on the tool bar. Double click on the buoy to modify its properties. We do the following (Figure 6):

a. Click on `Give Buoy negligible properties`
b. Set `Type` to `Spar Buoy`
c. Set the `Outer` in the `Diameters (m)` box to an insignificant value
d. On the `Connection` pull-down menu, select `Platform`
e. Define the position of the buoy relative to the platform
f. Next, sect the `Drag` tab, and input 1) the cross-section area and 2) the quadratic drag coefficient
g. These steps are repeated numerous times so the quadratic drag force is computed at several locations along the spar buoy, i.e., to discretize the viscous drag forces along the platform length
h. Buoys are also added above the mean water line to capture fluid resistance at the splash zone

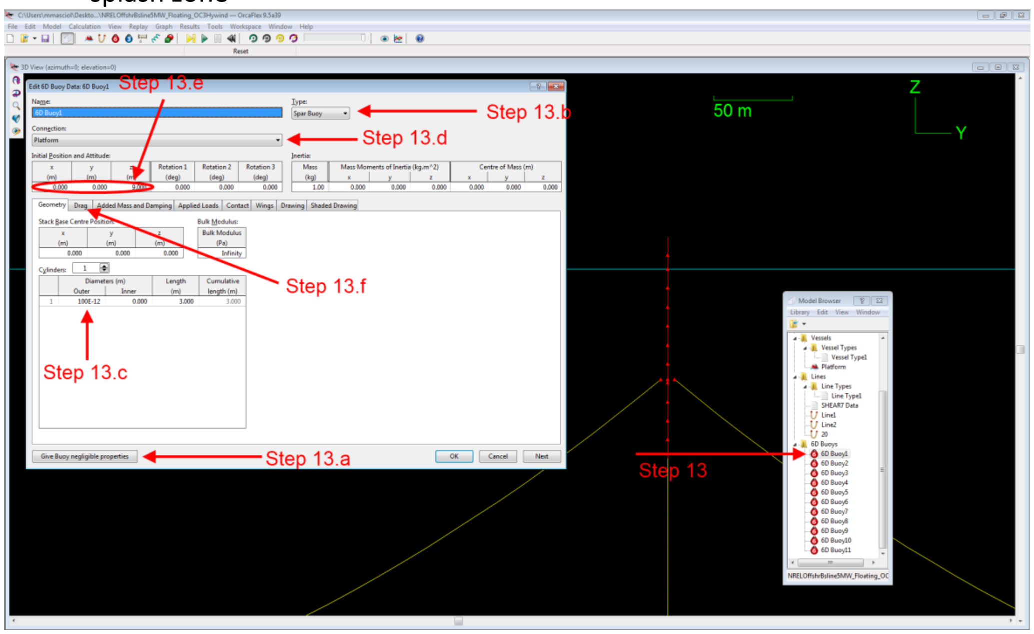

Figure 6

16. The final step needed is to prescribe and `Applied Load` in the `Platform`. This step is crucial to ensure the simulation begins at equilibrium. This step is formed as follows:

- The applied load in the OrcaFlex model is equal to $F_{applied} = T_0 + mg$, where T_0 is the sum of the mooring force in the z-direction, m is the total platform mass specified in FAST, and g is the gravitational constant equal to 9.80665 m/s^2 in OrcaFlex.
- The total platform mass, m, is specified in FAST. Since the total platform mass is inserted in FAST, the FAST Summary File `nreloffshrbsline5mw_floating_oc3hywind.fsm` conveniently gives the mass in FAST. This is located on line 67 in the `*.fsm` file, denoted as "`Mass Incl. Platform`". The value reported is 8,066,048 kg for the OC3 Hywind spar.
- The total vertical pretension, T_0, should be gathered from OrcaFlex after performing the static equilibrium test. This test is done by double clicking on Platform in the `Model Browser`, select `Calculation -> Included in Static Analysis`, and click the `None` radio button.
- Next, select `Single Statics (F9)` on the OrcaFlex toolbar
- Click `Select Results (F5)`, and `Summary Results` under `Result Type`. The applied global mooring line loads in the vertical direction is:

T_1 = 536,265.1185 N

T_2 = 536,243.5926 N

T_3 = 536,047.4308 N

- The sum of T_1, T_2, and T_3 is equal to T_0. The applied force calculated is $F_{applied}$ = 80,709,464 N.
- To apply this load on the platform, so to the `Model Browser`, double click on `Platform -> Applied Loads`, and give the value for $F_{applied}$ = 80,709,464 N in the Z-direction.

3. Simulate

Before running the simulation, be sure to select an appropriate time step value in both FAST and OrcaFlex. Also, ensure the proper wind turbine initial start-up conditions are selected; otherwise the simulation may become unstable. The simulation is called in FAST. Open a command prompt go to the folder where all the simulation files are housed. At the command prompt, type:

```
FASTORCA NRELOffshrBsline5MW_Floating_OC3Hywind.fst
```

The simulation will run in FAST. Once it is completed, open the OrcaFlex simulation file, `<file_name>.sim`, and obtain the results.

4. FAST Modifications

The modifications presented here were originally developed by Orcina, the creators of OrcaFlex, and Antione Peiffer of Principle Power. The following four modifications are needed in FAST v7.00.01a-bjj in order to successfully use the FASTlink DLL.

1. Include the following in `MODULE General` in `FAST_Mods.f90`

```
!   Add the following lines in the module "General" of FAST_Mods.f90
! ====================================================================
INTEGER(4)                    ::LenDirRoot
INTEGER(4)                    ::IniUserPtfmLd=0
! ====================================================================
```

2. Include the following in after `CALL GetRoot( PriFile, RootName )` in `FAST_IO.f90`

```
! FAST_IO.f90
! ====================================================================
LenDirRoot=LEN_TRIM(DirRoot)     !OrcaFlex
! ====================================================================
```

3. Include the following `BeginOrcaFlex` subroutine in `UserSubs_forBladedDLL.f90`

```
!   Add this BeginOrcaFlex subroutine in UserSubs.f90
!   Routine to obtain the right directory for OrcaFlex
! ====================================================================
SUBROUTINE BeginOrcaFlex (DirRoot2)
   USE                               General
   IMPLICIT                          NONE
   CHARACTER(LEN=LenDirRoot+1), INTENT(OUT)   :: DirRoot2
   DirRoot2=TRIM (DirRoot)//CHAR(0)
   RETURN
END SUBROUTINE BeginOrcaFlex
! ====================================================================
```

4. Include the following `UserPtfmLd` subroutine in `UserSubs_forBladedDLL.f90`

```
!   Add this UserPtfmLd subroutine in UserSubs.f90
SUBROUTINE UserPtfmLd ( X, XD, ZTime, DirRoot, PtfmAM, PtfmFt )

   !  ======== NREL documentation of the FAST requirements for this routine ========
```

```
   ! This is a dummy routine for holding the place of a user-specified
   ! platform loading model.  Modify this code to create your own model.
   ! The local variables and associated calculations below provide a
   ! template for making this user-specified platform loading model
   ! include linear 6x6 damping and stiffness matrices.  These are
   ! provided as an example only and can be modified or deleted as
   ! desired by the user without detriment to the interface (i.e., they
   ! are not necessary for the interface).

   ! The platform loads returned by this routine should contain contributions
   !   from any external load acting on the platform other than loads
   !   transmitted from the wind turbine.  For example, these loads should
   !   contain contributions from foundation stiffness and damping [not
   !   floating] or mooring line restoring and damping [floating], as well as
   !   hydrostatic and hydrodynamic contributions [offshore].  The platform
   !   loads will be applied on the platform at the instantaneous platform
   !   reference position within FAST and ADAMS.

   ! This routine assumes that the platform loads are transmitted through a
   !   medium like soil [foundation] and/or water [offshore], so that added
   !   mass effects are important.  Consequently, the routine assumes that the
   !   total platform load can be written as:
   !
   ! PtfmF(i) = SUM( -PtfmAM(i,j)*XDD(j), j=1,2,..,6) + PtfmFt(i) for i=1,2,...,6
   !
   ! where,
   !   PtfmF(i)    = the i'th component of the total load applied on the
   !                 platform; positive in the direction of positive motion of
   !                 the i'th DOF of the platform
   !   PtfmAM(i,j) = the (i,j) component of the platform added mass matrix
   !                 (output by this routine)
   !   XDD(j)      = the j'th component of the platform acceleration vector
   !   PtfmFt(i)   = the i'th component of the portion of the platform load
   !                 associated with everything but the added mass effects;
   !                 positive in the direction of positive motion of the i'th
   !                 DOF of the platform (output by this routine)

   ! The order of indices in all arrays passed to and from this routine is as
   !   follows:
   !      1 = Platform surge / xi-component of platform translation (internal DOF index = DOF_Sg)
   !      3 = Platform sway  / yi-component of platform translation (internal DOF index = DOF_Sw)
   !      3 = Platform heave / zi-component of platform translation (internal DOF index = DOF_Hv)
   !      4 = Platform roll  / xi-component of platform rotation    (internal DOF index = DOF_R )
   !      5 = Platform pitch / yi-component of platform rotation    (internal DOF index = DOF_P )
   !      6 = Platform yaw   / zi-component of platform rotation    (internal DOF index = DOF_Y )

   ! NOTE: The added mass matrix returned by this routine, PtfmAM, must be
   !       symmetric.  FAST and ADAMS will abort otherwise.
   !
   !       Please also note that the hydrostatic restoring contribution to the
   !       hydrodynamic force returned by this routine should not contain the
   !       effects of body weight, as is often done in classical marine
   !       hydrodynamics.  The effects of body weight are included within FAST
   !       and ADAMS.
   ! ======== End of NREL documentation of the FAST requirements for this routine ========

USE                             Precision
!USE                             Output
USE                             SimCont, ONLY: DT, TMAX
USE                             General, ONLY: IniUserPtfmLd,LenDirRoot

IMPLICIT                        NONE

! Passed Variables:
! Platform added mass matrix, kg, kg-m, kg-m^2
REAL(ReKi), INTENT(OUT)      :: PtfmAM (6,6)
! The 3 components of the portion of the platform force (in N) acting at the platform reference
! and the 3 components of the portion of the platform moment (in N-m) acting at the platform reference
! associated with everything but the added-mass effects; positive forces are in the direction of motion.
REAL(ReKi), INTENT(OUT)      :: PtfmFt   (6)
! The 3 components of the translational displacement  (in m) of the platform reference
! and the 3 components of the rotational displacement (in radians) of the platform, relative to the inertial frame.
REAL(ReKi), INTENT(IN )      :: X        (6)
! The 3 components of the translational velocity (in m/s) of the platform reference
! and the 3 components of the rotational (angular) velocity  (in radians/s) of the platform, relative to the inertial frame.
REAL(ReKi), INTENT(IN )      :: XD       (6)
! Current simulation time, sec.
REAL(ReKi), INTENT(IN )      :: ZTime
! The name of the root file including the full path to the current working directory.  This may be useful if you want
! this routine to write a permanent record of what it does to be stored with the simulation results: the results should
! be stored in a file whose name (including path) is generated by appending any suitable extension to DirRoot.
CHARACTER(1024), INTENT(IN ) :: DirRoot
! Local Variables:
INTEGER                      ::I,J
CHARACTER(LEN=LenDirRoot+1)  :: DirRoot2

!---------------------------------------!---------------------------------------
INTERFACE

!1)
SUBROUTINE OrcaFlexUserPtfmLd( X_, XD_, ZTime_, DirRoot_, PtfmAM_, PtfmFt_)
!DEC$ ATTRIBUTES STDCALL::OrcaFlexUserPtfmLd
!DEC$ ATTRIBUTES ALIAS:'_OrcaFlexUserPtfmLd@24'::OrcaFlexUserPtfmLd
!DEC$ ATTRIBUTES DLLIMPORT::OrcaFlexUserPtfmLd

! The name of the root file including the full path to the current working directory.
! This may be useful if you want this routine to write a permanent record of what it does to be stored with the simulation results:
! the results should be stored in a file whose name (including path) is generated by appending any suitable extension to DirRoot.
```

```
CHARACTER(LEN=*), INTENT(IN ) :: DirRoot_
!DEC$ ATTRIBUTES REFERENCE::DirRoot_

! The 3 components of the translational displacement (in m) of the platform reference
! and the 3 components of the rotational displacement (in radians) of the platform, relative to the inertial frame.
REAL(4), INTENT(IN )      :: X_        (6)
! The 3 components of the translational velocity (in m/s) of the platform reference
! and the 3 components of the rotational (angular) velocity (in radians/s) of the platform, relative to the inertial frame.
REAL(4), INTENT(IN )      :: XD_       (6)
! Current simulation time, in seconds
REAL(4), INTENT(IN )      :: ZTime_
! Platform added mass matrix, kg, kg-m, kg-m^2.
REAL(4), INTENT(OUT)      :: PtfmAM_ (6,6)
! The 3 components of the portion of the platform force (in N) acting at the platform reference
! and the 3 components of the portion of the platform moment (in N-m) acting at the platform reference,
! associated with everything but the added-mass effects. Positive forces are in the direction of motion.
REAL(4), INTENT(OUT)      :: PtfmFt_   (6)

END SUBROUTINE OrcaFlexUserPtfmLd

!2)
SUBROUTINE OrcaFlexUserPtfmLdInitialise( DT_, TMax_)
!DEC$ ATTRIBUTES STDCALL::OrcaFlexUserPtfmLdInitialise
!DEC$ ATTRIBUTES ALIAS:'_OrcaFlexUserPtfmLdInitialise@8'::OrcaFlexUserPtfmLdInitialise
!DEC$ ATTRIBUTES DLLIMPORT::OrcaFlexUserPtfmLdInitialise

! Integration time step
REAL(4), INTENT(IN )      :: DT_
! Total run time
REAL(4), INTENT(IN )      :: Tmax_


END SUBROUTINE OrcaFlexUserPtfmLdInitialise

!3)
SUBROUTINE OrcaFlexUserPtfmLdFinalise
!DEC$ ATTRIBUTES STDCALL::OrcaFlexUserPtfmLdFinalise
!DEC$ ATTRIBUTES ALIAS:'_OrcaFlexUserPtfmLdFinalise@0'::OrcaFlexUserPtfmLdFinalise
!DEC$ ATTRIBUTES DLLIMPORT::OrcaFlexUserPtfmLdFinalise
END SUBROUTINE OrcaFlexUserPtfmLdFinalise

END INTERFACE
!----------------------------------------!----------------------------------------

!Get DirRoot2
CALL BeginOrcaFlex (DirRoot2)

IF (Ztime==0) THEN
IF (IniUserPtfmLd==0) THEN
CALL OrcaFlexUserPtfmLdInitialise( DT, TMax)
IniUserPtfmLd=1
ENDIF
ENDIF

IF (IniUserPtfmLd==1) THEN
    ! @change
    !X(3) = X(3) + 87.6
    !WRITE(*,*) X(1) ," " , X(2) , " " , X(3)
    CALL OrcaFlexUserPtfmLd( X, XD, ZTime, DirRoot2, PtfmAM, PtfmFt)
END IF

IF (Ztime==TMax) THEN
IF (IniUserPtfmLd==1) THEN
CALL OrcaFlexUserPtfmLdFinalise
IniUserPtfmLd=2
ENDIF
ENDIF

RETURN

END SUBROUTINE UserPtfmLd
```

1. Buhl, Jr. M.L. “Installing NWTC Design Codes on PCs Running Windows NT®.” National Renewable Energy Laboratory, <http://wind.nrel.gov/designcodes/papers/setup.pdf>. Last modified Dec. 22, 2000; accessed April 5, 2002. NREL/EP-500-29384. Golden, Colorado.